Agroecological Sustainability Of An Ingenious Agrosystem Recognised Worldwide (The Ghouts Of Taibet Region)

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Abstract

The Ghout is an ingenious agrosystem registered by the FAO in the eastern Sahara of Algeria, characterized by the planting of palm trees in man-made craters at a depth that allows the roots to draw water directly from the water table. In Taibet, farmers remain steadfastly committed to this agrosystem, even though modern agriculture based entirely on irrigation is an option with very impressive results that could jeopardise the sustainability of traditional Ghout. The objective of this research is to assess the agroecological sustainability of traditional Ghouts based on the Farm Sustainability Indicators method through a simple random sample of ten farmers and an analysis of the results using descriptive analysis followed by an analysis based on the IDEA method model using Excel19 software. The results showed that the traditional Ghout agrosystem scored 67.5 points, favored by agricultural practices such as organic fertilisation and low pesticide use. Domestic diversity was found to be acceptable thanks to the enhancement and conservation of genetic heritage, while spatial organisation was disadvantaged by crop rotation and a lack of forage areas due to modest livestock farming. These results demonstrated the sustainability of the Ghout agrosystem, with the need for better spatial organisation. However, the adjustment of certain indicators to the local context is essential for a better assessment of the sustainability of the ingenious 'Ghout' agrosystem in Taibet.

Introduction

In the arid regions of Algeria, in the eastern Erg and before the advent of pumping technology and the use of deep aquifers for irrigation, the farmers of Taibet were among the first to develop a farming system based on the use of groundwater to create date palm gardens called 'Ghout'. These are excavations of varying sizes, around 10 to 15 meters deep (Remini, 2006), which contain a relatively large number of date palms, up to 200 (Côte, 2006; Kadri & Chaouche, 2019; Khechana et al., 2010; Remini & Souaci, 2019) and require neither irrigation nor drainage (Khadraoui & Taleb, 2012).

The Ghout agrosystem has been classified as a global agricultural heritage site by the FAO since 2011 (FAO, 2023) as one of the sites of the 'SIPAM' project (GIAHS- Globally Important Agricultural Heritage Systems), initiated by the FAO in 2002 with the aim of safeguarding and promoting these systems as elements of global agricultural and cultural heritage (FAO, 2023; Januel, 2010; Khezzani et al., 2016; Khezzani et al., 2023). In fact, the FAO has identified 67 systems in 22 countries as part of an initiative that emphasises both remarkable natural landscapes and agricultural practices aimed at ecosystem resilience, such as kihamba in Tanzania, rice-fish farming in China, the steep slope farming system of Nishi-Awa in Japan, the traditional vineyards of Soaveen in Italy, the historic irrigation system of Horta de Valencia in Spain, date production in the Siwa Oasis in Egypt, the Gafsa Oasis in Tunisia and the Ghout agricultural system in Algeria (FAO, 2023)

The existence of Ghouts in the Taibet region dates back to the 12th century (Januel, 2010; Kadri & Chaouche, 2019) during which farmers introduced new practices to improve and develop it, reaching a total of 13,364 Ghouts, of which 6,199 were abandoned following the rise in the water table, leaving only 7,165 Ghouts in good condition according to the first census of the wilaya of El Oued(Côte, 2006; Nouar, 2023; Remini & Souaci, 2019). Remote sensing confirms that the rate of Ghout disappearance is higher in the north of the Erg, while Taibet, located in the south-west, appears to be less affected by this widespread degradation and currently has 2,000 Ghouts confirmed by the agricultural services. This demonstrates the importance of the Taibet Ghouts in relation to the total number in the eastern Erg of the Algerian Sahara, accounting for nearly 30% of all Ghouts.

Traditionally, farmers choose a site on the Ghout where there is a depression (Ouatia) between the sand dunes and where the water table is fairly shallow (Remini, 2006). They begin to minimise this depth by transporting sand away from the basin. When they reach a depth of 1.5 to 2 m, they dig a circular pit with a radius of one meter and, at a depth of about 20 cm above the water table, they proceed to plant their small palm tree (Hachana) (Côte, 2006).

The Agricultural policy in the 1980s played a major role in encouraging farmers to develop new agricultural land, particularly under Law 83-18 on Access to Agricultural Land Ownership (APFA) (Chaouch, 2018; Côte, 1997). This expansion inevitably requires modern irrigation techniques, which pose the greatest threat to the survival of Ghouts (Remini & Souaci, 2019). Indeed, from a traditional Ghout agrosystem based solely on the exploitation of groundwater, some farmers are opting for a so-called 'mixed' agrosystem that uses irrigation, particularly drip irrigation and mini pivots (Côte, 2006; Januel, 2010; Kadri & Chaouche, 2019; Remini & Souaci, 2019). The two forms of agriculture still coexist, and the more recent one has not eliminated the older one, even though it reflects an active renewal, of agricultural activity. Given this desire to preserve Ghouts and the tendency of farmers to seek profit through profitable irrigated agriculture, this raises the question of the sustainability of this Ghout agrosystem.

Indeed, the issue of agricultural sustainability is now becoming a major concern for researchers and farmers alike. Allaire and Dupeuble (2004) report that the concept of sustainable agriculture is mobilising minds and reflections, and many researchers and associations have already come together to create methods for assessing the sustainability of farms. There are a great many such methods, and they do not all assess the same characteristics, use the same indicators or meet the same objectives. Each method has its own indicators, which depend on theoretical considerations, the conditions under (Julien Piqueray, 2013) which the research is carried out, and its own technique for data collection and analysis (Bockstaller et al., 2013; Zahm & Gassiat, 2010). Among these methods, we chose the Farm Sustainability Indicators (IDEA) method, launched in France in 1998. This is a relatively simple method, which is in line with global studies of agriculture in agrarian and ecological systems. It was designed to enable a diagnosis of the sustainability of farms based on direct surveys of farmers (Vilain et al., 2008; Zahm, 2003). In this context, we are particularly interested in the traditional Ghout agrosystem and aim to verify the agroecological sustainability of this agrosystem by applying the third version of the IDEA method, which has been used as the basis for several studies in arid and semi-arid areas around the world, such as the work of Baccar, (2017) in Morocco, Attia et al.(2022), in Tunisia and Algeria Belmessaoud (2011), Bekhouche (2011), Belhadi (2017) and Chaouch, et al., (2021).

MATERIALS AND METHODS

Location

The Taibet region is located 726 km south-east of the capital Algiers, 35 km from Touggourt and 60 km south-west of the city of El Oued, covering an area of 14,622 km² (Aliat, 2016). It is a district (daïra) consisting of three municipalities: Taibet, Bennaceur and Menaguer. As (Côte, 2006) aptly described it, it is 'a miniature Souf' composed of some fifteen localities, the largest of which is Taibet, and some fifteen relatively scattered groups of Ghouts with a farming system that is absolutely similar to that of the Souf (Figure 1).

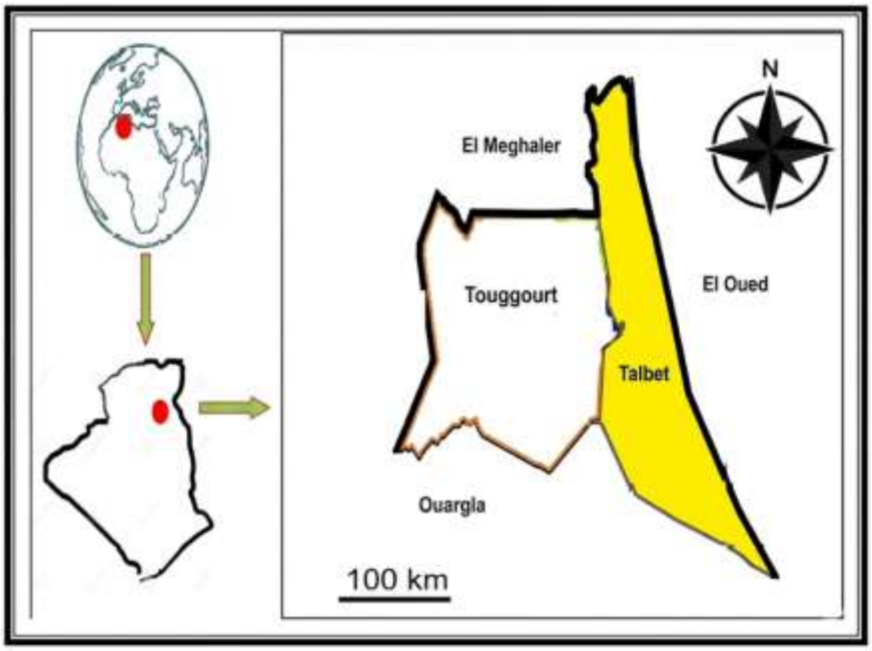

Figure 1. Location of the Taibet region (Gifex.com, 2023)

Main characteristics of the Taibet region

The Taibet region is characterised by a Saharan climate with mild winters (Côte, 2006), a topography and sand dunes belonging to the great eastern Erg (BNEDER, 2014). The soils are generally halomorphic, but Khadraoui and Taleb (2012) reports that, unlike the high salinity of oasis soils, the salinity of Ghout soils is low to negligible. As part of the eastern Sahara, it has a very large water reserve with three aquifers: the Continental Intercalary (CI), the Terminal

Complex (CT) and the water table (Khechana et al., 2010; OSS, 2003). The latter is responsible for the creation of the Ghouts and is characterised by high salinity with an electrical conductivity of 1.5 ms/cm to 17 ms/cm. (Aliat, 2016).

The specificity of agriculture in Taibet is the Ghout agrosystem, which is a hydro-agricultural system based on planting palm trees in craters in the middle of dunes, allowing the roots to seek water from the water table without any irrigation or drainage network (Côte, 2006; Khezzani et al., 2016; Zella & Smadhi, 2006). Starting with the planting of 2 to 4 palm trees, the Ghout is then enlarged by removing sand and expanding the circle of the Ghout (Figure 2) until it reaches 80 to 100 palm trees or even more. (Côte, 2006; Januel, 2010; Remini, 2006). Phoeniciculture is the oldest method of cultivation for nomadic farmers, offering them the possibility of moving around without having to worry too much about their palm trees (Côte, 2006). Currently, the region has 3,656 ha, with 1,500 ha devoted to palm cultivation, representing 41% of the UAA, 63% of which is cultivated in Ghouts (DSA, 2023).

Figure 2. Birth and enlargement of the Ghout

Assessment method

The assessment of the agroecological sustainability of the Ghout agrosystem is based on the IDEA method, whose theoretical foundations are in line with the systemic approach used in agricultural sciences. The study is based on surveys of ten (10) farmers using survey forms inspired by the IDEA method (Version 3) and expanded to include information essential to this study.

We based our findings on direct interviews with farmers and field observations. Statistical processing consisted of an initial descriptive analysis using Excel19 software, followed by an analysis of sustainability indicators based on the IDEA V3 method's own calculation file.

For the IDEA method, agroecological sustainability comprises three components and 18 indicators with scores totaling 100 points, as shown in Table 1(Vilain et al., 2008), which specifies that the rating grid assigns scores for items with values ranging from 0 to a theoretical maximum threshold specific to the indicator, with a compensation principle that avoids the pitfall of a single sustainability model.

Table 01: Agroecological scale of the IDEA method

Components	Indicators		Maximum values	
Diversity	A1	Diversity of annual and temporary crops	14	Total Capped at 33 units
	A2	Diversity of perennial crops	14	
	A3	Animal diversity	14	
	A4	Enhancement and conservation of genetic heritage	6	
	A5	Crop rotation	8	
Organisation of space	A6	Plot size	6	Total Capped at 33 units
	A7	Organic matter management	5	
	A8	Ecological Regulation Zone (ERZ)	12	
	A9	Contribution to environmental issues	4	
	A10	Enhancing the space	5	
	A11	Management of forage areas	3	
Agricultural practices	A12	Fertilisation	8	Total Capped at 34 units
	A13	Liquid organic effluents	3	
	A14	Pesticides	13	
	A15	Veterinary treatments	3	
	A16	Protection of soil resources	5	
	A17	Management of water resources	4	

RESULTS AND DISCUSSIONS

Descriptive analysis of Ghout operators and operations

Age of farmers

The age of the farmers surveyed ranges from 45 to 78 years old, with an average of 63.5 ±13.90, where the majority (Khezzani & Bouchemal) are over 60 years old and 40% are adults between 40 and 60 years old. This reflects the reality of the traditional agrosystem in arid areas, mirroring the general situation in the country. According to (MADR, 2003; (Adair et al., 2022), farmers are tending to get older and young people are turning away from agriculture in favor of less demanding occupations.

The dominance of older people can be explained by their mastery of agricultural practices and also by the fact that the Ghout agrosystem requires little monitoring outside peak periods. We noted the total absence of young people under the age of 40, and after meeting with a few young farmers outside our sample, we found that they were turning to other activities or other agrosystem such as market gardening, which offers products that are in high demand in a much shorter time, especially early produce, and also the possibility of changing or stopping this activity, while other young people prefer the new so-called mixed agrosystem, which combines the Ghout with the use of irrigation, aimed in particular at varying agricultural products.

Level of education

Linked to the dominance of older farmers in Ghout farms, half are illiterate and 20% have primary or secondary education (Figure 3), which is close to the results obtained by (Januel, 2010) . The proportion of farmers with a university education can be explained by the fact that university graduates of adult age have replaced their parents in the management of Ghouts, which can also be explained by their knowledge and motivation regarding the revival that this GIAHS project can bring about.

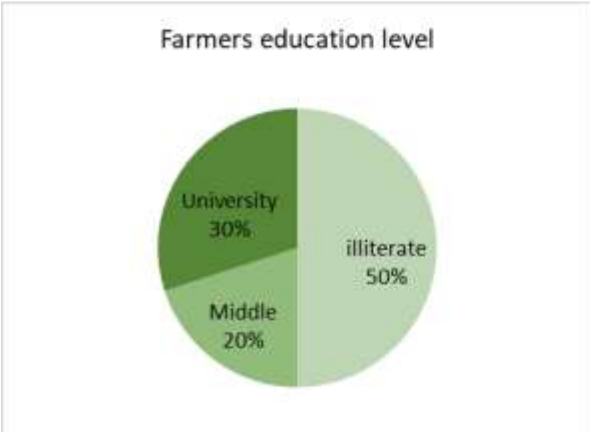

Figure 3. Educational levels of farmers in the Ghout agrosystem in Taibet

Size of farms, Ghouts and Useful agricultural area (UAA)

For the management of space in the context of the creation of the Ghouts, oral tradition tells us that this agrosystem is known by three boundaries: farms generally vary in size between 4 and 10 hectares, while Ghouts are smaller, ranging from 1 to 1.5 hectares, and the usable agricultural area (UAA) is very limited, ranging from 100 to 350 m² (Figure 4). These farms appear to be very small, and indeed they are, but what makes them important is that for centuries they have provided highly developed agriculture for one of the most tenacious societies. Given that the usable agricultural area in the Saharan region of Algeria is particularly limited, covering only 0.03% of the total area (Côte, 1993), we would like to highlight the importance of these small plots for traditional rural societies.

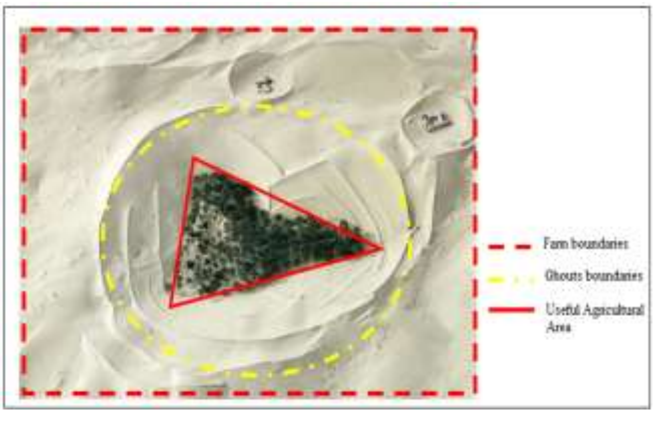

Figure 4. Presentation of the limits of exploitation, Ghout and SAU (produced by the author)

In our sample, farms are generally smaller than 10 ha, with 10% being small (1 to 3 ha) 40% medium-sized (3 to 6 ha) and 50% large (6 to 10 ha). However, the areas of Ghouts are much smaller (1 to 1.5 ha) due to the difficult terrain, and the UAA is still very low, varying between 100 m² and 350 m² (Figure 5).

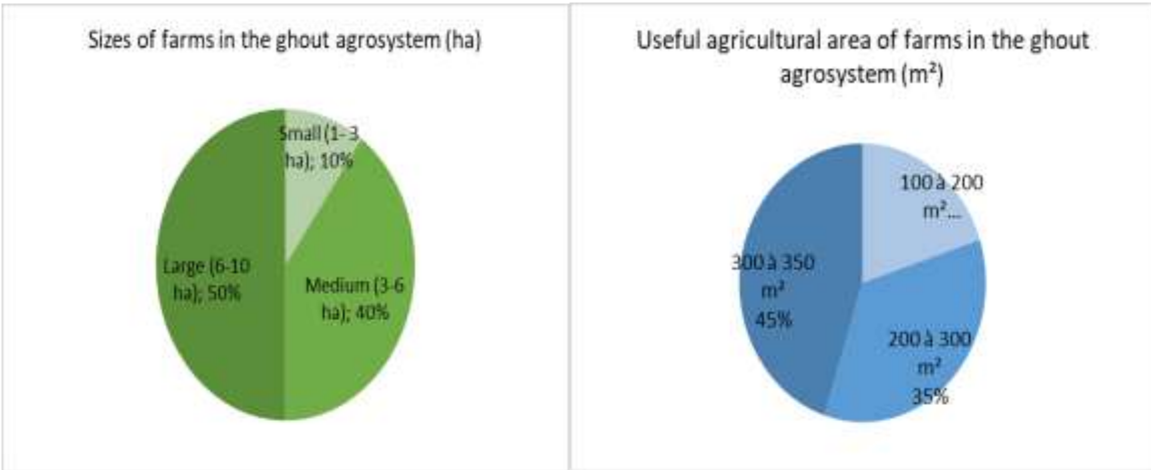

Figure 5. Sizes and useful agricultural areas of farms in the Ghout agrosystem

Number of palm trees and varietal composition

The Ghouts vary greatly in terms of the number of palm trees, ranging from 24 to 120 trees per farm, and also in terms of variety. The Deglet Nour variety dominates in all Ghouts thanks to its economic value and high yields, which can reach 200 kg per palm tree, followed by the Ghars variety with an average yield of 160 kg per palm tree. The Degla Beidha variety, which is relatively common in some farms due to its economic value linked to its export to African countries, accounts for around 15 to 20 palm trees with an average yield of 130 kg/palm tree. A few other varieties, such as Tenissine, Tantabouchet, Taourekhet and Tanslitte, number no more than 1 to 2 palms on some farms.

Farms status

This is an ingenious system invented by the indigenous people. Administratively, these lands are part of the private domain of the state, with perpetual use granted to farmers who do not, however, hold title deeds. This means that all farms are untitled properties obtained at different times through inheritance.

The boundaries of Ghout farms are determined by the ancient customs of the region, which we illustrate in Figure 6 below and which dictate that:

- From east to west: each farm has half the area separating it from the neighboring farmer;

- To the south: each farm has the entire area separating it from the neighboring farmer;

- To the north: the farm has a boundary with the Ghout counter or with the first palm tree of the neighboring farmer.

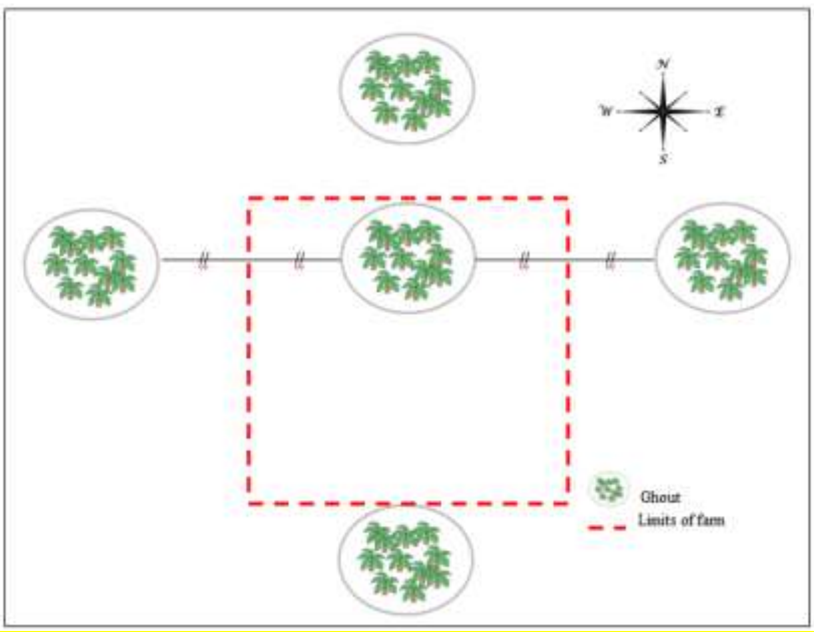

Figure 6. Limits of Ghout and farms (made by the author)

The convergence and multiplication of these Ghouts forms palm groves in the middle of the Erg, especially in places where the water table is a few meters below the surface (Chaouch, 2016; Côte, 2006). The following image shows a group of Ghouts in the Taibet region taken by satellite.

Figure 7. The Ghouts of Taibet

Agroecological sustainability of farms

According to the IDEA method, the agroecological scale is divided into three components: domestic diversity, spatial organisation and agricultural practices. There are 18 indicators in total.

Domestic diversity

The 'domestic diversity' component consists of four (4) indicators with an overall value of 18/33, or 54.54% of the theoretical maximum. The study highlights indicators with very high scores and others with fairly low or even zero sustainability scores.

The most favorable indicators are 'genetic heritage enhancement and conservation' and 'animal diversity'. The 'genetic heritage enhancement and conservation' indicator recorded an average of 6/6, or 100% of the theoretical maximum value. Indeed, the Ghars and Deglet Nour varieties are present in all farms, the Degla Baidha variety in more than half of the farms, and the Tawrakhet variety exists in only one farm and is considered a rare variety. Furthermore, we agree with (Chaouch et al., 2021), who reported that the lack of a reference framework for cultivated plant and animal species in the region poses a problem in terms of measuring local heritage, and that the related indicators cannot be assessed correctly.

The 'animal diversity' indicator averages 10.5/14, or 75% of the theoretical maximum score. This score is boosted by the presence of sheep, generally of the Barbarine breed (7 to 20 head) and/or goats of the Arbia breed (2 to 10 head) on most farms with around ten chickens. Camel breeding is now limited to three farms with 8 to 25 Chaâmbi camels, as these farmers have maintained their traditional way of life. It should also be noted that no other breeds have been introduced, thus preserving and safeguarding the local heritage.

The indicators with low scores are the 'diversity of perennial crops' indicator and the 'diversity of annual or temporary crops' indicator. The 'perennial crop diversity' indicator has an average score of 3/14, or 21.42% of the maximum theoretical score. This low average is due, on the one hand, to the total absence of grasslands and, on the other hand, to the low diversity of perennial species, which are limited to date palms alone. However, the 'diversity of annual or temporary crops' indicator is zero. This score can be explained by the particularity of the traditional Ghout system, in which farmers in the region do not use irrigation. Palm trees are planted at a depth where their roots can draw water directly from the water table, meaning that no annual or temporary crops can be grown.

Organisation of space

The 'spatial organisation' component comprises seven indicators with highly variable scores, giving an overall score of 14/33, or 42.42%. It falls below the average, with few indicators achieving good scores and the majority scoring zero.

The indicator with the highest score is 'plot size' with 6/6, or 100% of the theoretical maximum, which can be explained by the fact that the spatial units of the same crop are very small (0.1 and 0.35 ha) and do not pose an erosion problem. These very small areas, in accordance with the IDEA method, receive the maximum score because all farms are smaller than 1 ha on average, whereas the method sets a minimum of 8 ha.

The 'organic matter management' indicator is acceptable, with an average score of 3/5, or 60% of the theoretical maximum. This result is favored by the abundant use of camel dung and manure as organic fertilisers on all areas of most farms, and also by the fact that farmers do not use composted inputs. These figures confirm the findings of (Bel messaoud, 2011), which show that, for organic soil amendments, farmers are content to use dry organic manure from their livestock or purchased in small quantities to fertilise palm groves, and do not process any agricultural products on the farm.

The 'ecological regulation zone' indicator has a score of 5/12, or 41.66% of the theoretical maximum, and is considered low because it is based primarily on the percentage of UAA in the ecological regulation zone, which is very insignificant here due to the absence of runoff and water points, as the Ghout is an agrosystem without irrigation. In addition to these disadvantages, this agrosystem is characterised by the absence of permanent grasslands and the modest number of livestock. However, we have identified a strong point, which is the maintenance of the Ghout surroundings and their periodic development to prevent sand from entering the Ghouts, especially during windy seasons. As for the map locating the main environmental issues, it is currently completely absent from all farms in the country. According to Chaouch et al. (2021), this map has not yet been considered for the whole country.

The indicators 'Crop rotation', 'Contribution to environmental issues in the region', 'Land use' and 'Management of forage areas' have zero scores. The 'crop rotation' indicator is zero because the Ghout is an agrosystem characterised by date palm cultivation, with no underlying crops due to the lack of irrigation. It should be noted that this agrosystem has a negative score here because of the monoculture of date palms. Vilain (2008) specifies that in viticulture or arboriculture, the concept of arable land does not apply. Consequently, if the farm does not grow any annual crops, it does not benefit from any synergies linked to crop rotation and this indicator, therefore, has a value of zero.

For the indicator 'Contribution to environmental issues in the region', this is not a failure specific to the Ghout. In Algeria, specifications are not yet used to commit farmers to respecting the natural heritage. For the other two indicators, 'Valorisation of space' and 'Management of forage areas', it is the total absence of forage areas and internally consumed cereals that leads to zero scores.

Agricultural practices

The 'Agricultural Practices' component consists of seven (07) indicators, each of which received the maximum score, giving the component a very high score of 34 out of 34, or 100% of the theoretical maximum (Vilain et al., 2008)

The 'Fertilisation' indicator has an average score of 8 points. For the Ghout system in the Taibet region, farmers only use camel dung purchased at local markets or collected from grazing areas and therefore do not use any mineral fertilisers. Similarly, the 'Liquid organic effluents' indicator has a score of 3 points, as this agrosystem does not generate any liquid organic effluents.

The 'Pesticides' indicator scored 13 points thanks to the low level of intervention by farmers in the Ghout, which is limited to a few traditional Sulphur-based treatments used in very small quantities and on an occasional basis. At the same time, the 'Veterinary Treatments' indicator also scored 3 because veterinary treatment is very low, which is linked to the small number of animals on the one hand, and on the other hand, these animals are generally hardy and well adapted to the conditions of the region, and care is limited to traditional interventions without recourse to veterinarians.

The 'Soil Resource Protection' indicator has a score of 5 because farmers in the Ghout never plough or even simply turn the soil. They only carry out erosion control measures by building terraces and strips to prevent the advance of sand. At the same time, the 'Water Resource Management' indicator scores 4, which is a distinctive feature of this Ghout agrosystem, where irrigation is not provided by irrigation systems and water is drawn directly from the water table.

The 'Energy Dependence' indicator has a score of 10, as the fuel oil equivalent per hectare is below the minimum standard indicated in the IDEA grid in most farms, because farmers limit their use of electricity and use, for example, palm fronds and cournefs (dry parts of palm trees) as firewood.

Table 02: Items per indicator of the agroecological scale, IDEAV3 method

Indicator	**Items for score calculations**
Diversity (A1 to A4)	
A1: Diversity of annual and temporary crops	• Cultivated species (type and number) • Varieties: (type and number) • % of legumes in crop rotation (excluding PN and PT > 5 years)
A2: Diversity of perennial crops	Area of permanent and/or temporary grassland over 5 years old, as a percentage of UAA. Type and number of tree and vine species • Tree varieties • Vine varieties • Tree and vine rootstocks: • Agroforestry or any form of complementary use of trees and agricultural production
A3: Animal diversity	• Species (type and number)• Breeds (type and number)
A4: Enhancement and conservation of genetic heritage	• Regional breeds or varieties in their region of origin with an economic and heritage function (type and number)• Rare and/or endangered breeds, varieties and species with an economic and heritage function (type and number)
Organisation of space (A5 to A11)	
A5: Crop rotation	• Area under annual crops (or crops with a growing season of less than 18 months) occupying the largest proportion of the arable land • Arable land • Mixed cropping • Monoculture
A6: Plot size	• Area of the largest 'spatial unit of the same crop' • Average area of 'spatial units of the

	same crop'
A7: Organic matter management	•% of area where organic matter is recycled • % of organic matter composted
A8: Ecological Regulation Zone (ERZ)	• Area of existing ecological regulation zones: wetlands, floodplains, dry grasslands, grass strips, copses, rangelands, mountain pastures, isolated trees • Mapping of areas with environmental issues
A9: Contribution to environmental issues	• Area covered by compliance with territorialised specifications
A10: Enhancing the space	• Livestock density in LU/ha of LFA (land used for animal production). All land used for feeding livestock.
A11: Management of forage areas	• Mowed and grazed area • Permanent grassland area as a percentage of UAA • Silage maize area
Agricultural practices (A12 – A18)	
Fertilisation	Apparent nitrogen balance, -Presence of nitrate trap crops, -Mineral P and K supply
Liquid organic effluents	Absence of liquid organic A5 -Individual aerobic biological treatment of effluents with approved spreading only on the farm surfaces, -Collective treatment of effluents with approved spreading -Lagooning, composting, -No treatment on liquid effluents
Pesticides	-Pollutant pressure, -Biological control -Absence of recording book or rinsing device for tank bottoms in the field
Veterinary treatments	-Veterinary treatment, -Use of systemic dewormers
Protection of soil resources	-Soil work without turning, -Permanent meadow or grassy cover in vegetation, -Anti-erosion developments and practices (terraces, low walls, grassy strips, contour plowing, etc.), -Mulching, grassing of perennial crops, etc., -Burning of straw or vine shoots
Management of water resources	-Irrigation, -Irrigation device (and/or frost protection), -Pivot or front ramp irrigation, -Rotation of irrigated plots, -Individual sampling (borehole, stream, well), -Not declared and/or not equipped with a meter
Energy dependence	-Fuel oil equivalent per hectare, -Drying in a crib or in a solar barn or other heat saving and recovery device, -Photovoltaic, wind, biogas, -Production of pure vegetable oil, -Production and/or use of firewood,

Summary by indicator

The overall analysis by indicator, presented in the radar chart (Figure 8), shows that the Ghout agrosystem exhibits high variability across the 18 indicators of the agroecological scale. It shows that seven indicators have maximum scores, i.e. 100% of the theoretical maximum. These indicators are genetic resource conservation and enhancement, fertilisation, liquid organic effluents, pesticides, veterinary treatment, water resource management, soil resource protection and energy dependence. Two indicators have high scores above 50% of the theoretical maximum. These indicators are plot size and animal diversity.

The indicators with very low to zero scores are the very low scores for the two indicators of perennial crop diversity and ecological regulation zones, while four indicators have zero scores, namely contribution to the territory's environmental issues, crop rotation, land use and forage management.

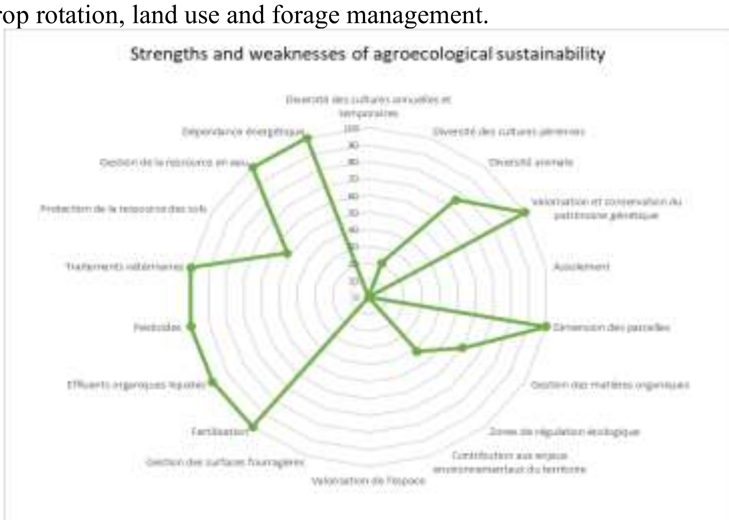

Figure 8. Strengths and weaknesses of agroecological sustainability

Overall analysis

Analysis of the three components of the agroecological scale for the Ghout agrosystem in the Taibet region gives an overall score of 67.5/100, which is satisfactory and demonstrates that agriculture has the technical and environmental assets to support its sustainability. The maximum score is recorded for the 'Agricultural Practices' component, capped at 34 points/34, or 100% of the theoretical maximum, followed by the ‘Domestic Diversity’ component with a score of 19.5 points out of 33, or 59%, and finally the component that constitutes the limiting factor for sustainability, ‘Spatial Organisation’, with a score of 14 points out of 33, not exceeding 42% of the theoretical maximum (Figure 9). This overall score on the agroecological scale indicates a predisposition towards healthy and sustainable development similar to irrigated agriculture in the arid areas of Algeria, which scored 70 points (BelhadiI, 2017) and far exceeding those in Tunisia with 65 points and a predominance of the Diversity component (Attia et al., 2022) and in Morocco with only 38.1 and a predominance of the Agricultural Practices component(Hakimi & Hamdoun, 2023).

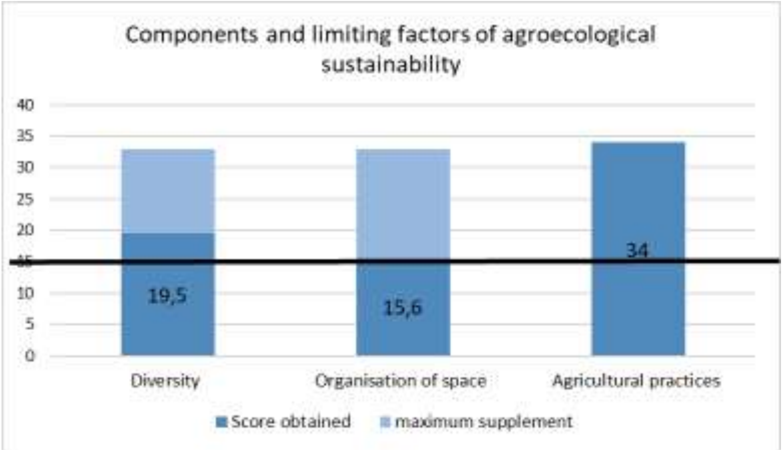

Figure 9. Limiting factor of agroecological sustainability

Conclusion

The Ghouts of Taibet are a faithful model of the eastern Erg, which for centuries has provided a suitable way of life for the farmers, herders and semi-nomads of this region. Analysis of agroecological sustainability using the IDEA method gives an overall score of 67.5% of the theoretical maximum, with the best result for the agricultural practices component, where farmers have demonstrated a very good command of the techniques essential for the development of farms, proving that this is indeed a sustainable system and that farmers are increasingly aware of its importance, as confirmed by the return of academics. The score for the diversity component is acceptable, with a shortfall in terms of annual crop diversity due to the lack of irrigation, but favored by the conservation of local genetic heritage. However, the spatial organisation component has the lowest score and is considered the limiting factor for reasons related to the very nature of Ghouts and, in some cases, the unsuitability of certain IDEA method indicators to the local context, without this being unfavorable for a correct assessment of the sustainability of farms in the Taibet Ghout agrosystem.

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